final rule provides the criteria for determining when analytic sampling information is sufficient for establishing an observed release (or observed contamination in the soil exposure pathway). The final rule also provides procedures to be followed when the SQL is unavailable and defines various types of detection and quantitation limits in the context of the HRS. (See § 2.3 of the final rule.)

H. Benchmarks

SARA requires that EPA give high-priority to sites that have led to closing of drinking water wells or contamination of principal drinking water supplies. To respond to this mandate, the proposed rule added health-based benchmarks to the ground water and surface water migration pathways; in addition, ecological-based benchmarks were added to evaluate sensitive environments targets in surface water. In the proposed rule, population factors were evaluated at Level I if a health-based benchmark had been exceeded. If actual contamination was present, but the benchmark was not exceeded, populations were evaluated based on two levels of contamination (i.e., Level II and Level III). Sensitive environments in the surface water migration pathway were evaluated based on two levels of actual contamination (exceeding benchmark or not exceeding benchmark). Where several hazardous substances were present below benchmarks, the percentages of their concentrations relative to their benchmarks were added to determine which level was used to assign values.

Of the commenters on this issue, most supported EPA's proposal to give extra weighting to sites where measured exposure-point concentrations exceed benchmarks. One commenter who dissented suggested giving extra weighting to sites where actual contamination is documented; documentation of an observed release (or observed contamination) would be the only criterion for assigning higher values to target factors, and the relationship of the concentration of hazardous substances to benchmarks would not be used. The other dissenting commenter suggested that EPA re-evaluate the role of health-based benchmarks in the HRS because common sense, and other laws, will discourage people from drinking water contaminated above benchmark levels, and because evaluating this factor will entail large resource expenditures for marginal gains in discrimination.

The final rule weights most targets based on actual and potential exposure to contamination across all pathways and threats, including those for which benchmarks were not originally proposed, because EPA believes that this approach both improves the ability of the HRS to identify sites that pose the greatest threat to human health and the environment and increases the internal consistency of the HRS. (See §§ 2.5, 2.5.1, 2.5.2, 3.3.1, 3.3.2, 4.1.2.3.1, 4.1.2.3.2, 4.1.3.3.1, 4.1.3.3.2, 4.1.4.3.1, 4.2.2.3.1, 4.2.2.3.2, 4.2.3.3.1, 4.2.3.3.2, 4.2.4.3.1, 5.1.3.1, 5.1.3.2, 6.3.1, 6.3.2, 6.3.4, 7.3.1, 7.3.2.) In the final rule, both the population factors and the factors reflecting the hazard to the nearest individual (or well or intake) are evaluated in relation to health-based benchmarks in all pathways. The sensitive environment factor in the surface water environmental threat is weighted in relation to ecological-based benchmarks; however, in the soil exposure and air migration pathways, the sensitive environment factor is weighted simply on the basis of exposure to actual contamination, and no benchmarks are used.

The Agency chose to use benchmarks in all pathways in response to comments that specifically suggested such a change; it is also responding to comments that the HRS should better reflect relative risks and that the approaches in all pathways should be consistent. The Agency has concluded that the concerns expressed by commenters outweigh the concerns about uncertainties in the evaluation of samples collected in air and soil and about the lack of regulatory standards and criteria on which to base soil or air benchmarks that led the Agency not to include benchmarks for those pathways in the proposed rule. In short, EPA carefully considered this point and concluded that the consistent application of benchmarks across all pathways provides for the most reasonable use of data given the purpose of the HRS as a screening tool.

EPA generally selected specific criteria based on applicable or relevant and appropriate requirements (ARARs), excluding State standards, that have been selected for the protection of public health and the environment as outlined in the NCP (55 FR 8666, March 8, 1990). In the HRS NPRM, EPA proposed to use MCLs, maximum contaminant level goals (MCLGs), and screening concentrations (SCs) based on cancer slope factors as drinking water benchmarks, and Food and Drug Administration (FDA) Action Levels as benchmarks for the human food chain threat. EPA also proposed to use Ambient Water Quality Criteria (AWQC) as ecological-based benchmarks for the environmental threat. EPA received 21 comments from 12 commenters on which benchmarks the HRS should use and whether additional information should be considered in establishing benchmarks. Opinion was divided on the use of specific types of benchmarks: three commenters supported the use of MCLs; three did not. Two commenters supported the use of MCLGs, two opposed such use, and one suggested that EPA consider the economic impact of using the value of 0 (i.e., the MCLG for a carcinogen) as a health-based benchmark. Two commenters suggested including relevant State drinking water standards, and one suggested including concentrations based on RfDs. One commenter expressed concern that the current lack of water quality standards for many substances might make the benchmark system ineffective in identifying sites that pose a significant threat to human health. Two commenters suggested that carcinogen weight of evidence should be used in establishing SCs (e.g., the individual risk level should be lower for a Class A carcinogen than for a Class B2 carcinogen). Two commenters suggested considering other important routes of exposure (e.g., inhalation of hazardous substances volatilized from water, or dermal contact with contaminated water) in establishing drinking water benchmarks.

EPA conducted a number of analyses on specific benchmarks and on the modification of factors to consider in establishing HRS benchmarks. As a result of public comments and these analyses, EPA has concluded that the HRS is improved by including concentrations based on nationally uniform standards, criteria, or toxicity values as health-based or ecological-based benchmarks in all pathways and threats. EPA's conclusion is based on several considerations. First, the addition of benchmarks across all pathways and the use of ARARs for those benchmarks improves linkages with the RI/FS process. That is, the HRS benchmarks will be those used most frequently during RI/FSs, and the additional points provided by equalling or exceeding a benchmark will aid in identifying areas requiring follow-up in the RI/FS. Second, the internal consistency of the HRS is improved by using benchmarks because concentrations measured at or above benchmark levels are treated in a parallel manner across all pathways, allowing more consistent and fuller use of the relatively costly sampling data collected during the SI. Third, the number of hazardous substances for which at least one health-based or ecological-based benchmark is available is increased, allowing for more uniform assessment of sites nationwide.

The benchmark criteria that the Agency has concluded are most appropriate for each pathway and threat are listed below. As discussed above, EPA agrees with comments suggesting that benchmarks also be used in the soil exposure and air migration pathways and has selected criteria for these pathways based upon the kinds of factors discussed above. While EPA believes the criteria for the soil exposure and air migration pathways in the final rule are appropriate, it is open to any comments that members of the public may wish to submit regarding these criteria and specifically solicits such comments at this time. EPA asks that any such comments be submitted on or before (30 days after the date of publication in the **Federal Register**).

For the final rule, EPA has selected the following types of benchmarks in each pathway and threat, subject to any revisions in the criteria for air and soil exposure that may be made in response to comments. (Benchmarks for radionuclides are discussed in Section III E of this preamble.)

• Benchmarks in the ground water migration pathway and the surface water drinking water threat include MCLs, non-zero MCLGs, screening concentrations (SCs) for non-cancer effects based on RfDs for oral exposures, and SCs for cancer based on slope factors for oral exposures and 10^{-6} individual cancer risk (see Table 3–10). Because SCs based on RfDs and slope factors are used as drinking water benchmarks, MCLGs with a value of 0 have been dropped as HRS benchmarks.

• Benchmarks in the surface water human food chain threat include FDA Action Levels for fish or shellfish, SCs for non-cancer effects based on RfDs for oral exposures, and SCs for cancer based on slope factors for oral exposures and 10^{-6} individual cancer risk (see Table 4–17).

• Benchmarks in the surface water environmental threat include AWQC and Ambient Aquatic Life Advisory Concentrations (AALACs); AALACs will be considered as they become available (see Table 4–22).

• Benchmarks in the soil exposure pathway include SCs for non-cancer effects based on RfDs for oral exposures, and SCs for cancer based on slope factors for oral exposures and 10^{-6} individual cancer risk (see Table 5–3).

• Benchmarks in the air migration pathway include National Ambient Air Quality Standards, National Emission Standards for Hazardous Air Pollutants (NESHAPs) that are expressed in ambient concentration units, SCs for non-cancer effects based on RfDs for inhalation exposures, and SCs for cancer based on slope factors for inhalation exposures and 10^{-6} individual cancer risk (see Table 6–14).

Several commenters suggested technical refinements for deriving health-based benchmarks. Although qualifying information is useful and important and is, in fact, used extensively in the RI/FS process, the benefits of including such information in the HRS must be balanced against its limited scope and purpose as well as the limited data available to determine concentration at the point of exposure. Consequently, in the final rule:

• All health-based benchmarks are set in reference to the major exposure concern for each pathway or threat (e.g., benchmarks in the air migration pathway are set in reference to inhalation only; benchmarks in drinking water, the human food chain threat, and the soil exposure pathway are set in reference to ingestion), except for radionuclides for which external exposure is also considered in the soil exposure pathway;

• All benchmarks are set in reference to uniform exposure assumptions that are consistent with RI/FS procedures (e.g., water consumption is assumed to be two liters per day; body weight is assumed to be 70 kg);

• State water quality standards and other State or local regulations are not included as benchmarks because they would introduce regional variation in the HRS;

• A hierarchy has been developed to provide a single benchmark concentration for each hazardous substance by pathway and threat; and

• Qualitative weight-of-evidence is not used in deriving SCs for carcinogens.

In the NPRM, EPA requested comments on how many tiers (levels) of actual contamination to consider when weighting populations relative to benchmarks (i.e., which of three alternative methods presented should be adopted). EPA received two comments on this issue and three related comments regarding the weighting factors for each level. One commenter supported Alternative 2 (i.e., use of two levels of observed contamination and one level of potential contamination). Another commenter suggested that Level II and Level III concentrations be combined to include the range of contaminant levels above background, but below health-based benchmarks. A third commenter suggested that the weighting factors for each level be reconsidered. A fourth commenter suggested that 1/1000 of a benchmark factor is inappropriate because it is excessively conservative and difficult to detect. The fifth commenter suggested that because Level III represents concentrations with cancer risks below 10^{-7}, populations exposed to Level III concentrations should not be considered in the population category of drinking water threats.

EPA conducted a number of analyses on the subject of benchmark tiers and has dropped Level III contamination. In the final rule, Level I contamination is defined as concentration levels for targets which meet the criteria for actual contamination (see § 2.5 of the final rule) and are at or above media-specific benchmark levels; Level II contamination is defined as concentration levels for targets which either meet the criteria for actual contamination but are less than media-specific benchmarks, or meet the criteria for actual contamination based on direct observation; and potential contamination is defined as targets that are potentially subject to releases (i.e., targets that are not associated with actual contamination for that pathway or threat). These three tiers are used to assign values to both the nearest individual (or well or intake) and the population factors. As a result of EPA's analyses of benchmark issues, the weighting assigned to Level I and Level II contamination has been changed and made consistent across pathways. For example, Level I populations are now multiplied by a factor of 10 in all pathways. As in the proposed rule, potentially contaminated populations and nearest individuals (or wells or intakes) are distance or dilution weighted.

The proposed rule summed the ratios of all hazardous substances to their individual benchmarks as a means of defining the level of actual contamination, and EPA requested comments on the appropriateness of this approach to scoring multiple substances detected in drinking water. Of the 10 comments in response to this proposal, nine strongly opposed the proposed approach, particularly when applied to drinking water standards (i.e., MCLs), MCLGs, and noncarcinogens. One commenter supported the proposed approach.

EPA has decided to retain the summing of ratios of hazardous substances to their individual benchmarks, but in a modified form. The final rule sums measures of carcinogenic and noncarcinogenic effects separately;

concentrations specified in regulatory limits (e.g., NAAQS, MCLs, or FDA Action Levels) are not included in the summing algorithm. EPA recognizes that a more precise estimate of relative risk would be obtained by summing the ratios of hazardous substances to their individual RfD-based concentrations by segregating substances according to major effect, target organ, and mechanism of action. In fact, such a segregation is recommended during the RI/FS. However, health-based benchmarks are used in the HRS to provide a higher weight to populations exposed to hazardous substances at levels that might result in adverse health effects. As a consequence, EPA believes that use of the summed ratios of hazardous substances within pathways and threats to their individual RfD-based benchmark levels is appropriate for the screening purpose of the HRS.

EPA proposed and solicited comments on a range of 10^{-4} to 10^{-7} for individual cancer risk levels of concern in establishing levels of actual contamination with respect to health-based benchmarks. EPA received eight comments concerning this risk range. Four commenters suggested restricting the range to 10^{-4} to 10^{-6}, primarily because this range would be consistent with risk levels identified in the NCP and used by other EPA regulatory programs. Three commenters said the SCs for carcinogens should be the 10^{-6} individual cancer risk level. One commenter stated that 10^{-4} to 10^{-7} generally is the risk range considered for Superfund response. The final rule defines only two levels of actual contamination: significantly above background and equal to or above benchmark, and significantly above background but less than benchmark. When an applicable or relevant and appropriate requirement does not exist for a carcinogen, EPA selects remedies resulting in cumulative risks that fall within a range of 10^{-4} to 10^{-6} incremental individual lifetime cancer risk based on the use of reliable cancer potency information. EPA has selected the 10^{-6} screening risk level in defining the HRS benchmark level for cancer risk because it is the lower end of the cancer risk range (i.e., 10^{-4} to 10^{-6}) identified in the NCP and used by other EPA regulatory programs.

Two commenters objected to assigning releases of substances with no benchmarks to Level II as a default value. One suggested assigning unknowns to Level III because substances that are frequently released or are known or suspected to cause health problems are studied before those that are not. The other objected because "the absence of data is not data."

Because EPA has decided to adopt a benchmark system incorporating only two levels of actual contamination, the default level is Level II. If none of the hazardous substances eligible to be evaluated at a sampling location has an applicable benchmark, but actual contamination has been established, the actual contamination at the location is assigned to Level II.

I. Use Factors

The proposed HRS included factors to assign values to uses of potentially affected resources in the three migration pathways: ground water use (drinking water and other) in the ground water migration pathway, drinking water and other use and fishery use in the surface water migration pathway, and land use in the air migration pathway.

EPA received a number of comments on each of these factors. The commenters raised specific objections to distinctions drawn among various potential uses and to the weights assigned to those uses. For example, for the ground water use factor, some commenters asserted that the HRS should not delineate between private and public water supply contamination. For the surface water use factors, a commenter recommended a range of assigned values for irrigation of commercial food or forage crops because of variations in rates of uptake of hazardous substances. For the land use factor, two commenters urged giving greater consideration to institutional land use because of the sensitive populations that would be exposed.

Partly in response to these comments, and in an effort to simplify the HRS, EPA has substantially revised the method of incorporating resource use information in targets factor categories. The field test indicated that collecting data on each of the use factors involved considerable effort at many sites. In addition, because of weighting factors applied to potentially contaminated populations, at sites with no actual contamination, use factors were contributing more to the targets value than were large populations. As some commenters pointed out, the use factors mixed concerns about human health with concerns about the value of the resource and, therefore, were partially redundant with population factors. To avoid redundancy with human health concerns as evaluated through the population factor, EPA has made major changes in how resource uses are evaluated and scored in the final rule.

In each migration pathway, the use factors have been replaced by a resources factor that assigns values to resources appropriate for the pathway. In addition, a resources factor has been added to the soil exposure pathway. The resources factor for a pathway is assigned a maximum of five points if any of the resource uses for that pathway exists within the target distance limit in the ground water or surface water migration pathway, within one-half mile of a source in the air migration pathway, or within an area of observed contamination in the soil exposure pathway. If none of the uses exists, the factor is assigned a value of 0.

The resources factor in the ground water migration pathway assigns a value of 5 for wells supplying water for irrigation of commercial food or commercial forage crops (five-acre minimum), watering of commercial livestock, as an ingredient in commercial food preparation, or as a supply for commercial aquaculture or for a major or designated water recreation area (excluding drinking water use)—for example, water parks (see § 3.3.3). A value of 5 is also assigned if the water in the aquifer is usable for drinking water, but not used.

The resources factor in the drinking water threat of the surface water migration pathway assigns a value of 5 if the surface water is designated by a State for drinking water use but not used, or is usable but not used for drinking water. In addition, points may be assigned for intakes supplying water for irrigation of commercial food or commercial forage crops (five-acre minimum), watering of commercial livestock, as an ingredient in commercial food preparation, or if the water body is used as a major or designated water recreation area (see § 4.1.2.3.3). The fishery use factor has been deleted to avoid double-counting of fisheries.

In the air migration pathway, the resources factor is assigned a value of 5 if there is commercial agriculture or commercial silviculture, or a major or designated recreation area within a half mile of a source (see § 6.3.3). The distance of one-half mile for the agricultural, silvicultural, and recreational areas was determined by the distance weighting factors for the air migration pathway, which reflect the rapid diminishing of air contaminant concentrations beyond one-half mile from a source. Therefore, resources beyond this distance are not considered in this pathway.

A resources factor has also been added to the resident population threat of the soil exposure pathway. The factor is assigned a value of 5 if there is commercial agriculture, commercial silviculture, or commercial livestock production or grazing on an area of observed contamination at the site.

J. Sensitive Environments

The proposed rule expanded the list of sensitive environments considerably and, for the surface water and air pathways, counted all sensitive environments within the target distance limit, rather than just the one with the highest assigned value; for the soil exposure pathway, only the sensitive environment assigned the highest value was counted. Potentially contaminated sensitive environments were distance/dilution weighted; in the surface water environmental threat, actual contamination of sensitive environments was evaluated on the basis of ecological-based benchmarks.

EPA received relatively few comments on issues related to sensitive environments. However, participants in the field test requested clarification of three categories of sensitive environments involving spawning areas, migratory pathways, and feeding areas critical for the maintenance of a fish species within a river system, coastal embayment, or estuary. In particular, critical migratory pathways and feeding areas were difficult to identify and seemed to provide little discrimination among surface waters in some areas of the country.

EPA has redefined critical spawning a eas to include shellfish beds, and has limited the areas to those used for intense or concentrated spawning by a given species. Critical migratory pathways and feeding areas have been combined into a single category and limited to anadromous fish (i.e., fish that ascend from the ocean to spawn), which face special problems in migrating substantial distances between the ocean and their spawning areas. These feeding areas are further restricted to only those areas in which the fish spend extended periods of time. Examples include areas where juveniles of anadromous species feed for prolonged periods (e.g., weeks) as they prepare to migrate from fresh water to the ocean, and holding areas along the adult migratory pathways.

Terrestrial areas used for breeding by large or dense aggregations of vertebrates (e.g., heron rookery, sea lion breeding beach) have been added to the list of sensitive environments to parallel the spawning areas listed for fish species. Water segments designated by a State as not attaining toxic water quality standards have been removed because these environments are already degraded and thus are not analogous to the other sensitive environments listed. Also, the assigned value for State designated areas for protection or maintenance of aquatic life has been changed from 50 points to 5 points (see Table 4–23 in final rule) to be consistent with the points assigned under the resources factor for State designated areas for drinking water use.

In response to public comment, National Monuments have been added to the 100-point category on the list of terrestrial sensitive environments considered under the soil exposure pathway. "State designated natural areas" and "particular areas, relatively small in size, important to the maintenance of unique biotic communities" were also added to the list of terrestrial sensitive environments in response to public comment. These latter two categories were already considered in the air and surface water pathway evaluation of sensitive environments. (See Table 5–5.)

The method for evaluating wetlands has been revised, partially because participants in the field test had difficulty identifying discrete wetlands. Some wetlands were patchy and could be classified as one large or many small wetlands. Other wetlands were divided by rivers or roads, or changed from one type of wetland to another, making it unclear whether more than one wetland should be counted. To eliminate these difficulties, wetlands are now evaluated on the basis of size and level of contamination. In the air migration pathway, wetlands are evaluated based on acreage and level of contamination (see § 6.3.4); in the surface water migration pathway, wetlands are evaluated by linear frontage along the surface water hazardous substance migration path and level of contamination (see § 4.1.4.3.1). Distinguishing among wetlands on the basis of size and level of contamination should improve the discriminating ability of the sensitive environments factor. In the drier portions of the country, where even small wetlands (e.g., prairie potholes) are very important, small wetlands may also qualify as "particular areas, relatively small in size, important to the maintenance of unique biotic communities."

Sensitive environments other than wetlands are not evaluated on the basis of size for several reasons. Most other HRS sensitive environments tend to be less common and less widely distributed nationally than wetlands (e.g., see EPA's 1989 *Field Test of the Proposed Revised HRS*) and, therefore, their numbers and boundaries tend to be easier to identify. In addition, the value of many sensitive environments is independent of size; for example, the size of a critical habitat of an endangered species may vary solely due to the type of species present. Furthermore, potential or actual contamination of even a small portion of many sensitive environments—for example, a wildlife refuge—tends to be viewed as unacceptable.

An ecosystem bioaccumulation potential factor has been added to the waste characteristics factor category of the surface water environmental threat in response to comments that hazardous substances that demonstrate an ability to bind to sediments and/or to bioaccumulate (e.g., PCBs, mercury) tend to pose the greatest long-term threats to aquatic organisms. The accumulation of hazardous substances in the aquatic food chain can result in adverse effects in aquatic species and in other animals that ingest aquatic species (e.g., waterfowl). The ecosystem bioaccumulation potential factor differs slightly from the bioaccumulation potential factor in the human food chain threat, primarily in that all BCF data are considered in deriving it and not just BCF data for human food chain organisms.

The EPA ambient aquatic life advisory concentrations (AALACs) have been added to the data hierarchy used to assign the ecosystem toxicity value (see § 4.1.4.2.1.1). The Natural Heritage Program alternative sensitive environment rating factors have been removed from the rule because of problems that arose during the field tests; field test participants found that the availability of information varied substantially among States. However, a Natural Heritage Program Data Center can assist in identifying many of the sensitive environment types listed in Tables 4–23 and 5–5.

K. Use of Available Data

A number of commenters stated that all available data should be used when scoring a site. Several cited the tiered approach to hazardous waste quantity as a model that could be applied to other factors. Under this method, where data are available, they would be used; where data are not available, defaults or more generalized approaches would be applied. Several commenters specifically suggested using this approach for ground water flow direction and for scoring mining sites. These commenters argued that it would be less expensive and time-consuming to use available data when scoring a site than to wait until the remedial investigation to consider the additional information.

EPA considered modifying the HRS to allow the use of additional data, but determined that further expanding the HRS to account for varying levels of data availability is inconsistent with the HRS's role as an initial screening tool. Adding tiers to various factors to accommodate the use of all available data would make the HRS considerably more difficult to apply and could lead to substantial inconsistencies in how sites are investigated and evaluated. EPA Regions and States would have to determine, for each set of data presented, whether the data quality was good enough for the data to be considered. Debates over decisions on data quality could delay scoring and, ultimately, delay cleanup at sites. Therefore, the Agency believes that the limited use of tiers in the final HRS represents a reasonable tradeoff between the need to limit the complexity of the system and the desire to accommodate risk-related information that is generally outside the scope of a site inspection.

L. Ground Water Migration Pathway

The proposed rule included a number of significant changes in the ground water migration pathway: new hydrogeologic factors were added; populations were distance weighted unless exposed to actual contamination; a maximally exposed individual (MEI) factor was added; the target distance limit was extended; a mobility factor was added and combined with toxicity; and a wellhead protection area factor was added. Figure 5 shows the proposed ground water migration pathway and the final rule pathway.

Ground water flow direction. Neither the original HRS nor the proposed HRS directly considered ground water flow direction in evaluating targets. The proposed HRS indirectly considered ground water flow direction by weighting populations based on actual and potential contamination of drinking water wells.

EPA received 50 letters from 40 commenters on this issue; 27 letters responded to the ANPRM, 21 to the NPRM, and two to the field test report. Commenters included eight States, three Federal agencies, the mining, petroleum, chemical, and cement industries, utilities, and professional engineers. The commenters supported the consideration of ground water flow direction data, at least in some circumstances. Numerous commenters urged the use of ground water flow direction data when they are either available or easily obtained. They suggested several methods to incorporate flow direction, including:

- Considering use of a radial impact area when directional release routes can be determined. Only a half circle with a three-mile radius for the downgradient portion (and a half-mile radius for the rest of the circle) should be considered when scoring;
- Differentiating between upgradient and downgradient areas using topographic maps, evaluating water levels at wells, and noting the presence of major surface water bodies;
- Expending the effort to obtain accurate data and considering selected upgradient locations as a precaution against unanticipated anomalies;
- Excluding drinking water wells where analytical data prove no contamination is present;
- Having a "professional" review available information and conduct a site visit;
- Using available flow direction data and developing regionally based defaults when no data are available;
- Installing piezometers to determine flow direction in the PA/SI phase and when no ground water flow data are available;
- Incorporating ground water flow direction into the "depth to aquifer" and "distance to nearest well/population served" scores; and
- Affording responsible parties the opportunity to determine flow direction.

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Figure 5

Ground Water Migration Pathway

PROPOSED HRS

Likelihood of Release	X	**Waste Characteristics**	X	**Targets**
Observed Release or Potential to Release Containment Net Precipitation Depth to Aquifer/ Hydraulic Conductivity Sorptive Capacity		Toxicity/Mobility Hazardous Waste Quantity		Maximally Exposed Individual Population Ground Water Use Wellhead Protection Area

FINAL HRS

Likelihood of Release	X	**Waste Characteristics**	X	**Targets**
Observed Release or Potential to Release Containment Net Precipitation Depth to Aquifer Travel Time		Toxicity/Mobility Hazardous Waste Quantity		Nearest Well Population Resources Wellhead Protection Area

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Commenters suggested that data on ground water flow are either readily available or can be easily obtained at reasonable cost and are no more imprecise than other aspects of the HRS. Some commenters stated that the level of effort required to estimate the direction of ground water flow is no greater than that required to determine other hydrogeologic parameters in the HRS.

EPA reviewed a range of options for considering ground water flow direction in evaluating targets. For the reasons discussed above under "Use of Available Data," the Agency decided that it was not feasible to adopt a tiered approach in the targets factors for evaluating ground water flow direction. EPA does not agree that increased accuracy warrants the increased complexity of accounting for ground water flow direction, because this level of accuracy is not required for a screening tool that is intended to assess relative risk. This level of accuracy, however, is needed to determine the extent of remedial action and, therefore, is appropriate at the time of the RI.

EPA disagrees with the argument that determining ground water flow direction is no more difficult than determining other ground water factors. Aquifer interconnections and discontinuities as well as hydraulic conductivity and depth to aquifer, which are evaluated in the final rule, are geologic features that are unlikely to change over the short-term. In contrast, ground water flow direction can be influenced by factors such as seasonal flows and pumping from well fields. In addition, the ground water flow direction may be different in each aquifer at the site, and the direction of hazardous substance migration is not always the same as the direction of ground water flow. Therefore, data on ground water flow direction would need to be considerably more extensive than would the data required to document the other hydrogeologic factors. EPA notes that in the final rule, many of the other hydrogeologic factors considered have been simplified and the sorptive capacity factor has been dropped. EPA also notes that ground water flow direction was not identified in SARA as a portion of the HRS requiring further examination, even though ground water flow direction was not considered in the original HRS and the Agency had received criticism similar to the above comments prior to enactment of SARA.

Although the final rule does not consider ground water flow direction directly in evaluating targets, it does consider flow direction indirectly in the method used to evaluate target populations. If wells have not been contaminated by the site, as the commenters assume upgradient wells would not be, the population drawing from those wells is distance weighted and, thus, populations drawing from the wells would have to be substantial before a large number of points could be assigned. Moreover, in addition to providing a measure of the population at risk from the site, the target factors afford a measure of the value of the ground water resources in the area of the site and of the potential need for expanded uses of the ground water.

Aquifer interconnections. Aquifer interconnections facilitate the transfer of ground water or hazardous substances between aquifers. The final rule specifies that if aquifer interconnections occur within two miles of the sources at the site (or within areas of observed ground water contamination attributed to sources at the site that extend beyond two miles from the sources), the interconnected aquifers are treated as a single aquifer for the purposes of scoring the site. Thus, for example, when an observed release to a shallow aquifer has been identified, targets using deeper aquifers interconnected to the shallow aquifer are included in the evaluation of the combined aquifer. This approach is common to the original as well as the revised HRS.

In practice, EPA has found that studies in the field to determine whether aquifers are interconnected in the vicinity of a site will generally require resources more consistent with remedial investigations than SIs, especially where installation of deep wells is necessary to conduct aquifer testing. Thus, EPA has in the past relied largely on existing information to make such determinations and the Agency finds it necessary to continue that approach. Examples of the types of information useful in identifying aquifer interconnections were given in the proposed rule. This information includes literature or well logs indicating that no lower relative hydraulic conductivity layer or confining layer separates the aquifers being assessed (e.g., presence of a layer with a hydraulic conductivity lower by two or more orders of magnitude); literature or well logs indicating that a lower relative hydraulic conductivity layer or confining layer separating the aquifers is not continuous through the two-mile radius (i.e., hydrogeologic interconnections between the aquifers are identified); evidence that withdrawals of water from one aquifer (e.g., pumping tests, aquifer tests, well tests) affect water levels in another aquifer; and observed migration of any constituents from one aquifer to another within two miles. For this last type of information, the mechanism of vertical migration does not have to be defined, and the constituents do not have to be attributable to the site being evaluated. Other mechanisms that can cause interconnection (e.g., boreholes, mining activities, faults, etc.) will also be considered. While the descriptive text has been removed from the rule, the approaches mentioned in the proposed rule will be used in making aquifer interconnection determinations. In general, EPA will base such determinations on the best information available; in the absence of definitive studies and where costs of field studies are prohibitive, the Agency will rely on expert opinion (e.g., U.S. Geological Survey staff or State geologists). In the absence of such information, EPA assumes that aquifers are not interconnected.

Ground water potential to release factors. EPA proposed replacing the depth to the aquifer of concern and permeability factors of the original HRS with depth to aquifer/hydraulic conductivity and sorptive capacity factors. EPA received more than 75 comments on these factors, in addition to general comments on evaluating ground water potential to release in response to the ANPRM.

Several commenters supported consideration of depth to aquifer in evaluating the ground water migration pathway. One commenter stated that use of a depth to aquifer/hydraulic conductivity matrix, which was intended to reflect travel time to ground water, was an improvement over considering these two parameters individually and additively. Concerns were raised, however, about how to determine depth to aquifer. In addition, commenters stated that the two-mile radius for evaluating hydrogeologic factors should be extended to four miles, while others commented that the distance should be measured from vertical points as near to the source as possible.

Commenters generally supported the proposal to include hydraulic conductivity, although many believed that the proposed method was too complicated; several commenters suggested that the single least conductive layer(s) should be used. Another concern was the lack of data for determining hydraulic conductivity. One commenter stated that unless data can confirm that the geologic strata extend throughout the entire area of a site, assigning a hydraulic conductivity value is highly questionable.

Some commenters offered alternative approaches to evaluating hydraulic conductivity. These included replacing the proposed method with:

• Assigned "confidence levels" tied to professional estimates based on regional data and judgment;

• Consideration of actual travel time in the unsaturated zone; or

• An assumption of maximum hydraulic conductivity among the various geological layers below the site.

More than 20 comments were received on the sorptive capacity factor, but there was little consensus among the commenters. A number of commenters agreed that the factor should be added, but stated that the approach was not detailed enough and that more waste- and site-specific information should be required. Other commenters agreed that the factor was an improvement, but said that sorptive capacity should be dropped because the waste- and site-specific information needed for an accurate evaluation cannot be collected during a screening process. Others said that it was too complex as proposed and should be dropped.

Based on these comments and the field test results, EPA examined the depth to aquifer/hydraulic conductivity and sorptive capacity factors. The examination showed that the lowest hydraulic conductivity layer(s) accounted for almost all of the travel time to the aquifer if a one-foot or three-foot minimum layer thickness was used. Accordingly, in the final rule, the depth to aquifer/hydraulic conductivity factor has been replaced with a simpler factor, travel time, which is determined using a matrix of the hydraulic conductivity and thickness of the lowest hydraulic conductivity layer(s) with at least a three-foot thickness. (See § 3.1.2.4 and Table 3-7 of the final rule.)

To conform with the change limiting the travel time factor to the least conductive layer(s), and to meet the goal of simplification, a change to the sorptive capacity factor was necessary. The proposed rule evaluated this factor using all layers between the source and the aquifer. In reexamining this factor, EPA concluded that depth to aquifer is one of the major parameters affecting total sorbent content, at least within the HRS ranges for the factor. Depth to aquifer also indirectly reflects geochemical retardation mechanisms because, all else being equal, the effect of these retardation mechanisms increases as the depth to aquifer increases. At the field test sites, using only the layer(s) of lowest hydraulic conductivity decreased the calculated sorbent content between 10 and 99 percent. For these reasons, EPA has decided to replace the sorptive capacity factor with a depth to aquifer factor. (See § 3.1.2.3 and Table 3-5 of the final rule).

M. Surface Water Migration Pathway

The proposed rule made major changes to the evaluation of releases or threatened releases to surface water. The pathway was divided into four threats: drinking water, human food chain, recreational use, and environmental. Other changes included consideration of flood potential; revision of potential overland flow; addition of dilution weights for potentially contaminated populations; extension of the target distance limit to 15 miles; revision of the persistence factor to consider more degradation mechanisms; addition of a bioaccumulation factor for evaluation of human food chain toxicity/persistence and populations; addition of ecosystem toxicity to evaluate the environmental threat; and addition of a maximally exposed individual factor (MEI) factor to the drinking water threat. Figure 6 shows the proposed rule and the overland flow/flood migration component of the surface water migration pathway in the final rule.

Recreational use threat. SARA stated that the HRS should consider threats to surface water used for recreation and drinking water, and the proposed HRS included a recreational use threat in the surface water migration pathway. A number of States, several companies and trade associations, and two Federal agencies identified problems with the proposed recreational use threat. Some commenters objected to weighting it as heavily as the drinking water threat, while others suggested that evaluating the threat was too complicated for use in a screening tool. Many commenters said that proposed methods for assigning values to recreation areas were too broadly drawn and that a limited number of recreation areas should be considered. Two commenters suggested using actual attendance data, and one commenter suggested that recreational uses be considered in other pathways as well.

EPA's field test indicated that the recreational use threat evaluation was too complex for HRS purposes and, at the same time, was not very accurate. Several field test participants commented that the recreation target population was difficult to evaluate and that the approach for determining population was inaccurate and time-consuming. In addition, the population factor did not provide meaningful discrimination among sites. The proposed rule used the physical characteristics (e.g., capital improvements) of a recreational site as the basis for determining the distance limit used to evaluate population, but because major and minor sites may have the same types of capital improvements (e.g., boat ramps, picnic facilities), the same distance limit could be associated with a minor recreation area and a major recreation area. The alternative approach would be to require actual use data to evaluate targets; however, site-specific population data are not available for many recreation areas, making it difficult to obtain accurate estimates of the population at risk. The target distance limits, which ranged from 10 to 125 miles, also contributed to the problems with evaluating targets. The Agency invited comments on refining these calculations; no alternative approaches were suggested, and EPA did not identify viable alternatives.

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Figure 6

Surface Water Migration Pathway

PROPOSED HRS

Likelihood of Release **X**

Observed Release
or
Potential to Release

By Overland Flow
- Containment
- Runoff
- Distance to Surface Water

By Flood
- Containment
- Flood Frequency

Drinking Water Threat

Waste Characteristics	**X**	**Targets**
Toxicity/Persistence		Maximally Exposed Individual
Hazardous Waste Quantity		Population
		Surface Water Use

+

Human Food Chain Threat

Waste Characteristics	**X**	**Targets**
Toxicity/Persistence/ Bioaccumulation		Population
Hazardous Waste Quantity		Fishery Use

+

Recreational Use Threat

Waste Characteristics	**X**	**Targets**
Toxicity/Persistence/Dose Adjusting Factor		Population
Hazardous Waste Quantity		

+

Environmental Threat

Waste Characterisitics	**X**	**Targets**
Ecosystem Toxicity/ Persistence		Sensitive Environments
Hazardous Waste Quantity		

Figure 6

Surface Water Migration Pathway - Overland Flow/Flood Component

FINAL HRS

Likelihood of Release X **Drinking Water Threat**

Observed Release
or
Potential to Release

By Overland Flow
- Containment
- Runoff
- Distance to Surface Water

By Flood
- Containment
- Flood Frequency

Drinking Water Threat

Waste Characteristics	X	**Targets**
Toxicity/Persistence		Nearest Intake
Hazardous Waste Quantity		Population
		Resources

+

Human Food Chain Threat

Waste Characteristics	X	**Targets**
Toxicity/Persistence/ Bioaccumulation		Food Chain Individual
Hazardous Waste Quantity		Population

+

Environmental Threat

Waste Characteristics	X	**Targets**
Ecosystem Toxicity/ Persistence/Bioaccumulation		Sensitive Environments
Hazardous Waste Quantity		

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EPA is also concerned that many qualities of recreation areas (e.g., uniqueness, attractiveness, value) cannot be readily quantified or measured, which poses significant problems for a screening tool. Therefore, the recreational use threat has been removed from the final rule. Instead, factors related to recreational use are being included in the assessment of resource factors in the air, surface water, and ground water migration pathways. (See the discussion of resources factors above and §§ 3.3.3, 4.1.2.3.3, 4.2.2.3.3, and 6.3.3 of the rule.) Recreational use is also a major component of the evaluation of the attractiveness/accessibility factor in the soil exposure pathway (see § 5.2.1.1 of the rule).

Human food chain. SARA requires that EPA consider "the damage to natural resources which may affect the human food chain * * *." Accordingly, the surface water migration pathway of the proposed rule included evaluation of threats to human health via the aquatic food chain.

A number of commenters suggested that terrestrial food chain threats should also be evaluated because most of the food eaten in the United States originates on land, and the terrestrial human food chain is, therefore, more important than the aquatic human food chain. Commenters specifically stated that the HRS should account for human food chain threats involving irrigated crops, livestock, and game animals. One commenter stated that the SARA mandate would not be fulfilled if only aquatic human food chain threats were evaluated.

After conducting an investigation into possible methods, EPA determined that it would not be practical to include a separate evaluation of terrestrial human food chain threats in the HRS. The terrestrial food chain is more complex and site-specific and is less understood than the aquatic food chain, and its assessment requires considerably more data. These factors render evaluation of the relative risks associated with the terrestrial human food chain well beyond the capability of a screening system such as the HRS. The final rule, therefore, does not separately evaluate terrestrial human food chain threats. These threats are, however, considered indirectly under the resources target components in the air migration pathway, ground water migration pathway, soil exposure pathway, and drinking water threat portion of the surface water migration pathway.

The proposed rule required the estimation of bioaccumulation potentials for hazardous substances posing threats via the human food chain. One commenter stated that the estimation of bioaccumulation potentials requires excessive time and resources, and that this step should be dropped from the HRS.

EPA disagrees and considers the bioaccumulation potentials of hazardous substances to be among the most important factors determining the degree of human health threat posed by substances via the human food chain. Substances that do not bioaccumulate pose less of a threat via the human food chain than substances that bioaccumulate, all else being equal. Conversely, substances with high bioaccumulation potentials can pose very significant threats via the human food chain even if they are only moderately toxic, or are present in modest quantities. EPA believes that compiling bioaccumulation potential tables will reduce the effort and resources required to score this factor.

EPA received several comments stating that bioaccumulation potential was not given sufficient weight in the evaluation of human food chain threats. EPA evaluated the use of bioaccumulation potential during the field test and determined that there was considerable uncertainty related to this factor, in part because of major differences in uptake associated with different species in different environments. In addition, bioconcentration values have been computed for only a few species for most substances. In light of this uncertainty, EPA decided that bioaccumulation potential should not be given additional weight in the HRS. In addition, as part of the structural changes discussed in Section III B, the bioaccumulation potential factor was moved from the targets factor category to the waste characteristics factor category so that it is evaluated consistently with the other waste characteristics factors that reflect exposure. As part of these changes, the use of the bioaccumulation potential factor in selecting the substance posing the greatest hazard also has been modified.

The final rule broadens the definition of actual contamination of the human food chain by modifying one criterion and adding a new criterion defining actual contamination. The proposed rule defined a fishery as actually contaminated if (1) the fishery was closed as a result of contamination and a substance for which the fishery was closed had been documented in an observed release from the site, or (2) a tissue sample from a human food chain organism from the fishery was found to contain a hazardous substance at a concentration level exceeding the FDAAL for that substance in fish tissue and the substance had been documented in an observed release from the site. In both cases, at least a portion of the fishery must be within the boundaries of the observed release.

Under the final rule, the former criterion (closed fishery) remains essentially unchanged. The latter criterion (tissue contamination) has been modified: A fishery is considered actually contaminated if the concentration of a hazardous substance in tissue of an essentially sessile benthic human food chain organism from the watershed is at a level that meets the criteria for an observed release from the site and at least a portion of the fishery is within the boundaries of the observed release. A new criterion has also been added: A fishery is considered actually contaminated if a hazardous substance having a bioaccumulation potential factor value of 500 or greater either is present in an observed release established by direct observation or is present in a surface water or sediment sample at a level that meets the criteria for an observed release from the site and at least a portion of the fishery is within the boundaries of the observed release. Only the portion of a fishery within the boundaries of an observed release is considered actually contaminated.

EPA broadened the definition of actually contaminated fisheries on the basis of field test results. With the more narrow definition in the proposed rule, few actually contaminated fisheries were identified because:

(1) Closed fisheries did not exist at most sites;

(2) Hazardous substance concentration data from tissues of applicable organisms were available for only a small portion of fisheries; and

(3) FDAALs exist for only a relatively small number of hazardous substances.

The final rule also introduces two levels of actually contaminated fisheries or portions of fisheries:

- Level I: Applicable when concentrations of site-related hazardous substances meeting the criteria for actual contamination of the fishery equal or exceed the benchmark concentration levels established in the final rule based on FDAALs, screening concentrations corresponding to elevated cancer risks, and screening concentrations corresponding to elevated chronic, non-cancer toxicity risks via oral exposures. The final rule allows Level I contamination to be established based on hazardous substance concentrations in tissue samples from "organisms other than essentially sessile benthic organisms" (e.g., fish, lobsters, crabs), even though these organisms cannot be used to establish observed releases or actual contamination.

• Level II: Applicable to all actually contaminated fisheries (or portions of actually contaminated fisheries) not meeting Level I criteria.

The final rule assigns human food chain populations associated with Level I concentrations tenfold greater weight than those associated with Level II concentrations. The final rule also describes the procedures for determining, where applicable, the part of a fishery subject to Level I concentrations, the part subject to Level II concentrations, and/or the part subject to potential contamination.

EPA received several comments suggesting that, to be consistent with the other threats, a maximally exposed individual factor should be incorporated into the human food chain threat. The Agency agrees, and to provide this consistency the final rule incorporates a maximally exposed individual factor (the food chain individual) into the human food chain targets factor category. As with similar factors in other pathways and threats, the food chain individual is assigned points according to the level of contamination. Where actual contamination of a fishery is documented, the food chain individual factor is assigned 50 points for Level I and 45 points for Level II concentrations. Where no actual contamination of a fishery is documented, but there is documentation of an observed release of a hazardous substance having a bioaccumulation potential factor value of 500 or greater to a watershed containing a fishery within the target distance limit, the food chain individual is assigned a value of 20 points. Where there are no observed releases to surface water or no observed release of a hazardous substance with a bioaccumulation potential factor value of 500 or greater, but a fishery is present (i.e., there is a potentially contaminated fishery) within the target distance limit, the food chain individual is assigned points ranging from 0 to 20, depending on the dilution weight assigned to the associated surface water body.

The proposed rule estimated human food chain production of actually contaminated or potentially contaminated fisheries based on harvest data or stocking data for those fisheries, if available. Where such data were not available, production estimates were based on productivity of the surface water body or the estimated standing crop of aquatic biota in the fisheries. The proposed rule included a table of standing crop default values for estimating human food chain production of the fishery.

EPA received numerous comments to the effect that the standing crop default table was difficult to use, provided several different values for some water bodies and none for others, and provided unreliable data. Several commenters stated that standing crop values are not an appropriate basis for estimating aquatic human food chain production. One commenter pointed out that standing crop estimates do not correlate well with harvest for various water body types. Another commenter stated that estimates of harvest from fish and game officials are preferable to standing crop default values because standing crop is a measure of biomass (weight of all edible living organisms in the water body) rather than productivity.

EPA agrees with the commenters. In the final rule, estimates of fishery human food chain production are based on fish harvest data (including stocking data) as opposed to standing crop data. When site-specific data are not available, harvest rates are to be estimated based on the average harvest per unit area for the particular water body type under assessment and the geographic area in which the water body is located.

Ground water discharge to surface water. A number of commenters and field test participants suggested that the HRS should consider the potential impact of ground water discharges to surface water because contaminated ground water can be a significant source of surface water contamination. Field test participants noted that some sites have no overland flow route, but surface water can be contaminated through ground water discharges.

EPA agrees and has added a ground water to surface water migration component to the surface water migration pathway. Figure 7 shows the structure of this component. The surface water migration pathway, therefore, now includes two components: The overland flow/flood migration component, which retains the structure of the surface water migration pathway as proposed (except for the changes discussed in this preamble), and the new ground water to surface water migration component. Either or both components may be scored; if both are scored, the surface water migration pathway score is the higher of the two scores. EPA selected the higher of the two scores rather than combining them because, if scores were combined, the amount of hazardous substances at the site available to migrate via each component would have to be apportioned between the two components. The site-specific data needed to determine the appropriate apportionment are rarely available.

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Figure 7

Surface Water Migration Pathway - Ground Water to Surface Water Component[1]

FINAL HRS

Likelihood of Release **X** **Drinking Water Threat**

Observed Release
or
Potential to Release
- Containment
- Net Precipitation
- Depth to Aquifer
- Travel Time

Waste Characteristics X	**Targets**
Toxicity/Mobility/Persistence	Nearest Intake
Hazardous Waste Quantity	Population
	Resources

+

Human Food Chain Threat

Waste Characteristics X	**Targets**
Toxicity/Mobility/Persistence/ Bioaccumulation	Food Chain Individual
Hazardous Waste Quantity	Population

+

Environmental Threat

Waste Characteristics X	**Targets**
Ecosystem Toxicity/Mobility/ Persistence/Bioaccumulation	Sensitive Environments
Hazardous Waste Quantity	

New component.

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